Taylor Larrechea

+9.5/10

Current-Voltage Characteristics of Circuit Elements **Physics 132 Lab**

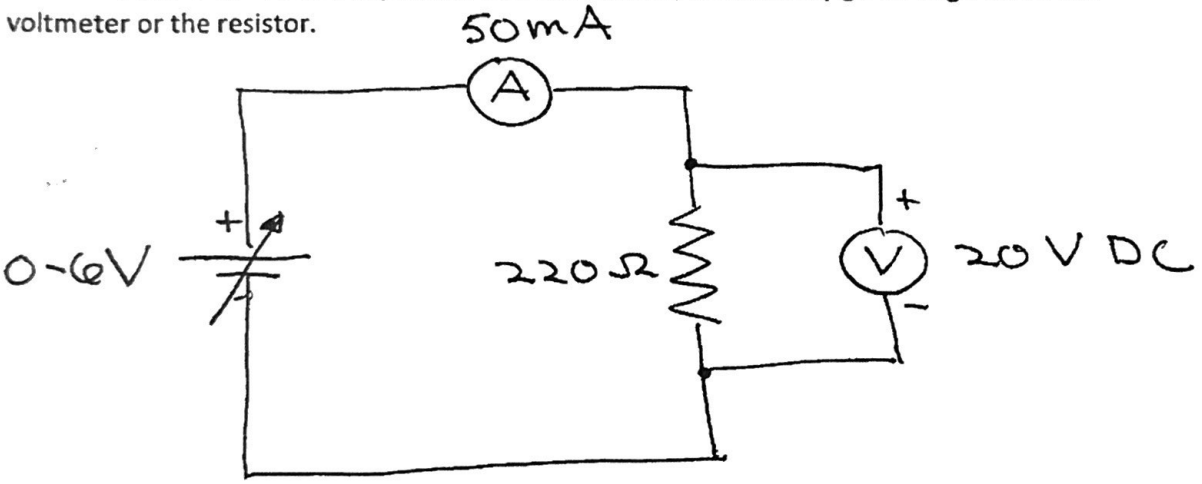
The quantities current (I) and potential difference or voltage (ΔV) are easily measured in a circuit. In today's lab you will investigate the relation between current and voltage for three different circuit elements: a commercial resistor, an incandescent light bulb, and a semiconductor device called a diode.

I. Ohmic Circuit Element: 220 Ω Resistor

Commercially manufactured resistors are ohmic devices that are made in a huge range of resistance values and power ratings. In this section you'll measure ΔV vs I for a commercial 220 Ω resistor.

First, use your digital volt-ohm-milliammeter (VOM) on its "ohm" setting to measure the resistance of your resistor. Record the value in your notebook; it should be within a few ohms of the specified value.

With your power supply OFF, wire the circuit shown below. Notice that the ammeter is connected in series with other circuit elements; all current must pass through the ammeter. The voltmeter is connected in parallel with the resistor; current may go through either the voltmeter or the resistor.



Resistor Circuit

NOTE: Never connect an ammeter in parallel with circuit elements, this may damage the meter! The ammeter should be connected to its 50 mA range, the voltmeter set on 20 volts DC, if you have the option.

After wiring this circuit, have it checked with the lab instructor. When you get the OK you can turn the power supply on. FIRST, set the current control about ½ way and turn the voltage control all the way counter-clockwise (off). Now turn the power supply ON and adjust the

voltage control until the voltage is about 5 volts. Measure and record ΔV across the resistor and the current through the resistor.

1. Does the value of $R = \Delta V/I$ agree with the resistance measured using the ohmmeter setting of your digital VOM?

2. Reverse the orientation of the resistor in the circuit and measure ΔV and I again. Does orientation of a resistor matter?

3. Next measure and record in a table values of I and ΔV for current values of about I = 0, 5, 10, 15, 20, and 25 mA. Adjust the current by turning the voltage control knob on your power supply. Enter the data in Excel and plot ΔV vs I (with ΔV on the vertical or "y" axis). Your curve should be a straight line. Do a linear fit to get the slope of the curve. Does the slope agree with the resistance value?

II. Incandescent Bulb

In this section you will investigate the I-V characteristics of a #48 incandescent bulb. First measure the resistance of your bulb with your digital meter, like you did with the resistor. Then replace the resistor in your first circuit with the #48 incandescent bulb in its socket. You'll also need to connect the ammeter using its 500 mA input. Measure and record in a table values of ΔV and I for I = 0, 50, 100, 150, 200, and 250 mA.

1. Plot ΔV vs I (ΔV on the "y" axis again) in your lab notebook. Use at least ½ of a full page for your graph. Give the graph a title and label the axis. Your graph should <u>not</u> be linear as it was with the resistor! Can you give an explanation why the tungsten filament in the bulb does not appear to be "ohmic"? I thought metal wires are supposed to be ohmic!

2. The temperature dependence of resistance in a metal can be approximated with the equation

$$R = R_o[1 + \alpha\Delta T]$$

For a tungsten wire $\alpha = 4.5 \times 10^{-3}\ (°C)^{-1}$. Assuming that room temperature is 20 °C, use this equation and your I-V data to estimate the temperature of the filament when I = 250 mA. Here R_o will be the bulb's resistance at room temperature.

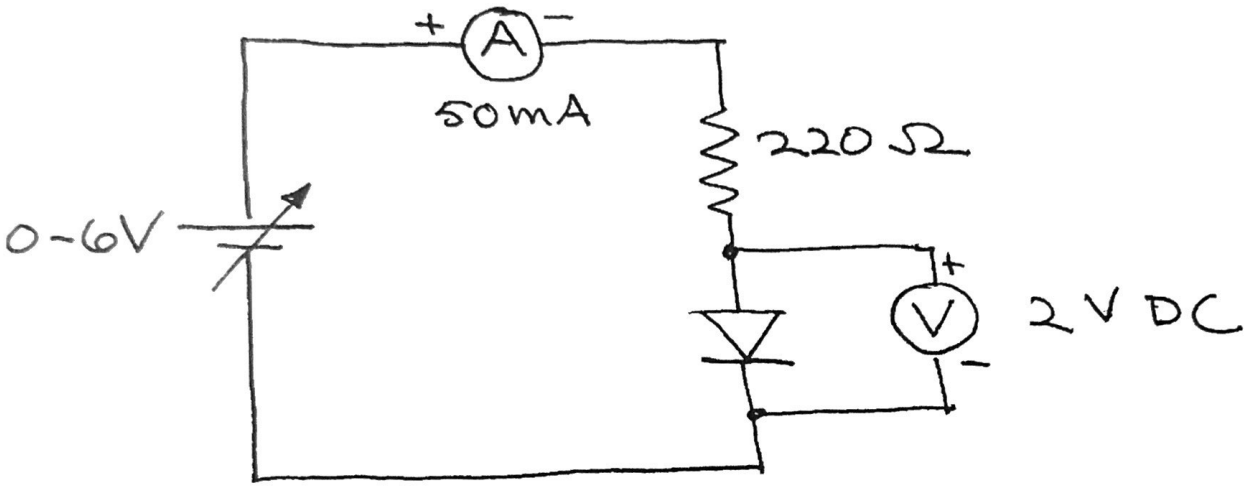
III. Diode

A diode is a semiconducting device with very non-linear I-V characteristics. The circuit symbol and a sketch of an actual diode are shown below. With a diode, its orientation does matter!

Diode schematic

Diode appearance

Wire the circuit shown below. Notice that the voltmeter should be set on its 2 V DC setting, if you have the option. Be sure to get the diode orientation correct.



Diode circuit

1. Set the supply voltage to about 5 volts and measure the current and the voltage across the diode. Record your values. Now reverse the orientation of the diode in the circuit and repeat your 5 volt current and voltage measurements. (You may need to change your volts DC range for the reverse orientation.) Are your measurements the same for the two orientations?

2. Orient the diode to its original (conducting) orientation and measure and record I and ΔV for I = 0, 2, 5, 10, and 20 mA. As before, adjust current by varying the voltage control knob of the power supply. Make a graph of I vs ΔV in your lab notebook, using at least ½ of a full page for your graph. Plot I on the vertical "y" axis for this graph.

3. Is the diode ohmic?

A diode in a circuit acts like a gate valve in a circuit: when "forward biased" it conducts with about a 0.7 voltage drop, when reverse biased it does not conduct at all!

use b)

$E_i = E_f$

$PE_i = PE_f$

$$PE_{13i} + PE_{23i} + PE_{12i} = PE_{13f} + PE_{23f} + PE_{12} + KE_\alpha$$

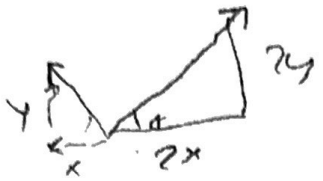
$PE_{13i} = PE_{23i}$ and $PE_{13f} = PE_{23f}$

$$2PE_{13i} + PE_{12} = 2PE_{13f} + PE_{12} + KE_\alpha$$

$$2\left(\frac{-|e|\,2|e|}{r_i}\right) + \frac{4|e||e|}{r} = 2\left(\frac{-|e|\,2|e|}{r_f}\right) + \frac{4|e|^2}{r} + KE_\alpha$$

$r_1 \simeq 1.12\ nm \qquad r_2 \simeq .71$

draw $\vec{E}_{net}$



$E = |E_x|_x + 3|E_y|_y$

cosθ sinθ

2|e|

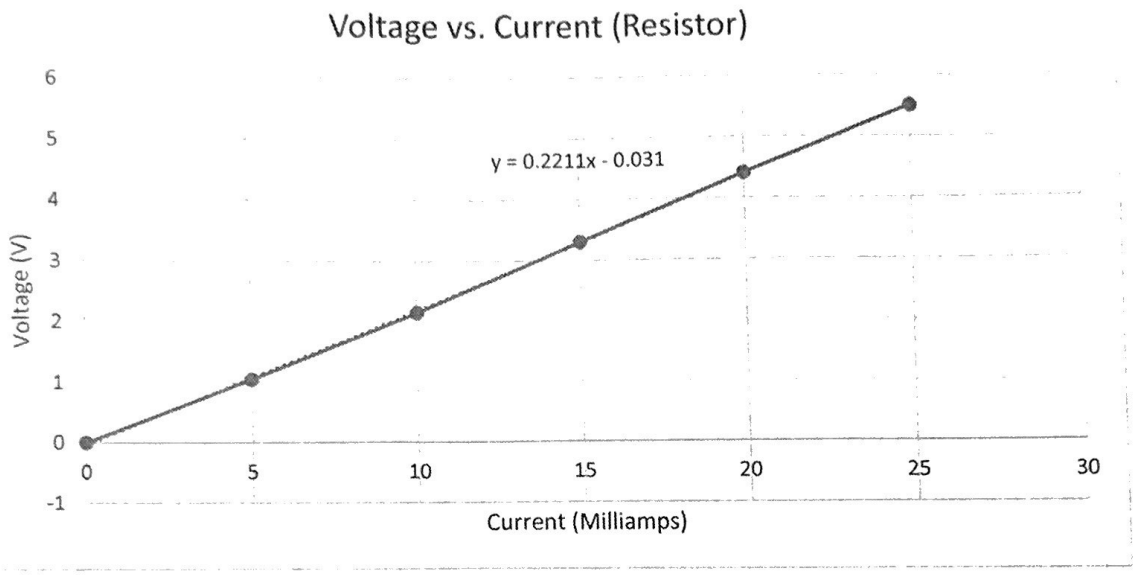
|e|

+

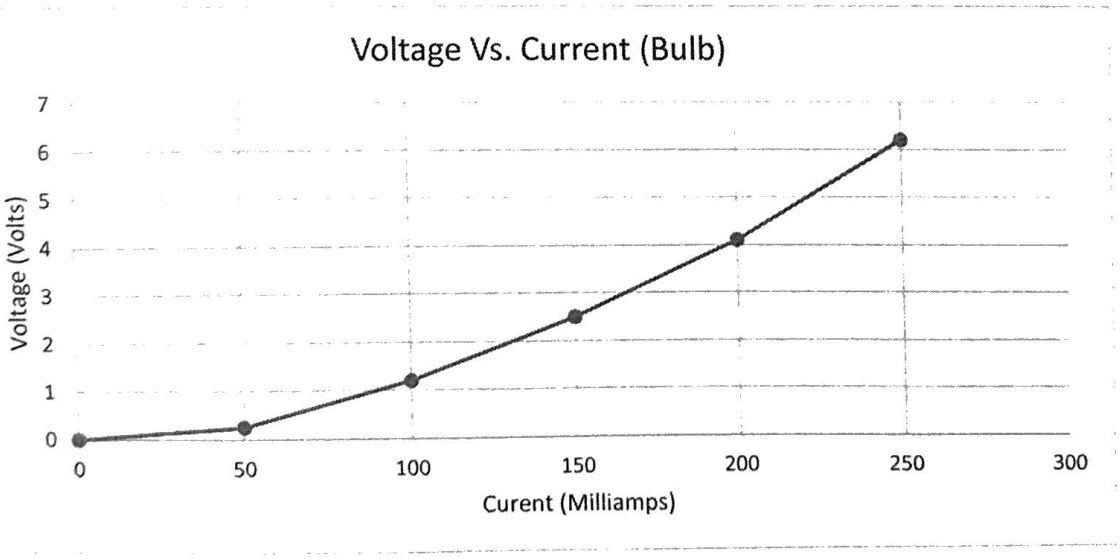
o

+

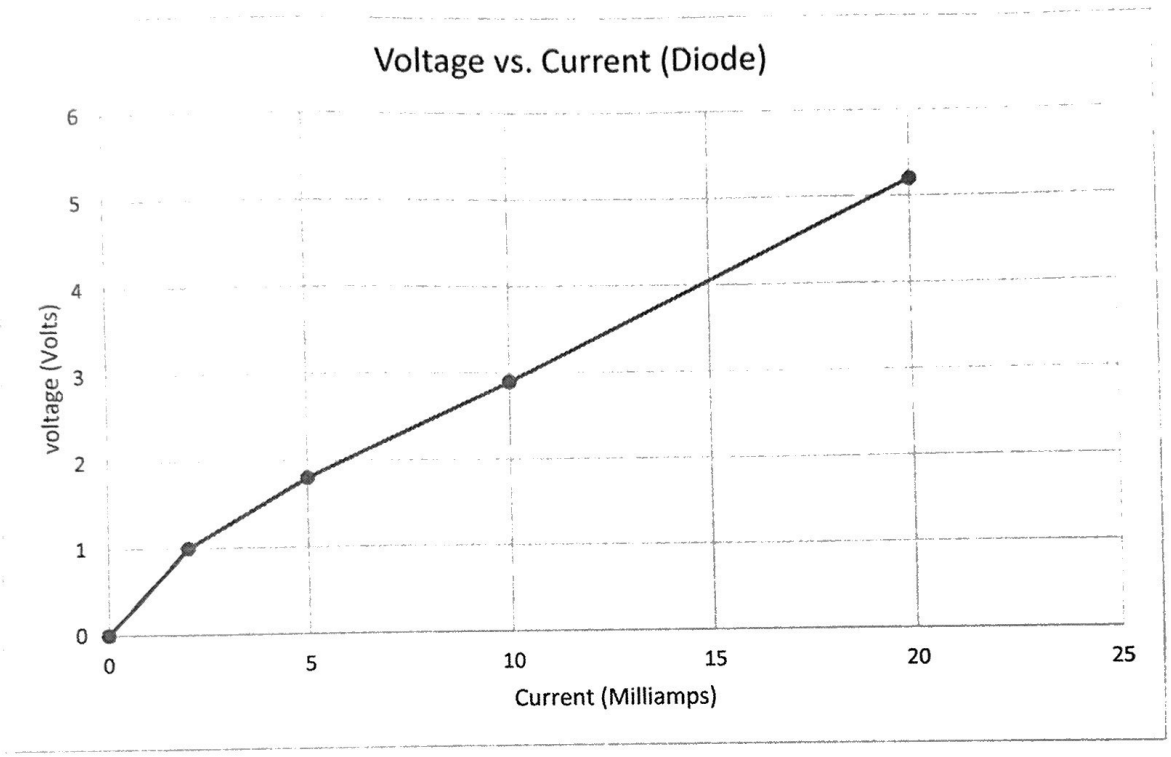
Current	Voltage
0	0
5	1.05
10	2.15
15	3.3
20	4.4
25	5.5



Current	Voltage
0	0
50	0.25
100	1.2
150	2.5
200	4.1
250	6.2



Current	Voltage
0	0
2	1
5	1.8
10	2.9
20	5.2



Part 1

A) 220 Ω's

1.) $\Delta V = IR$ $\quad \Delta V = 4.95\,V$ $\quad R = \frac{4.95V}{2.25\times10^{-3}}$

$I = 22.5\times10^{-3}\,A$

$V = 220\,\Omega$ $\quad$ measured $= 5.06\,V$

$\Delta V = 4.95\,V$ $\quad R = \frac{\Delta V}{I}$ $\quad R = 220\,\Omega$

$I = 2.25\times10^{-3}$

2) An ohmmeter does not $\Delta V = 5.06\,V$

$I = 22.5\times10^{-3}\,mA$

$R = \frac{\Delta V}{I} = \frac{5.06V}{22.5\times10^{-3}} = 220\,\Omega$

3) It does agree with the resistance value

Part 2

1) $R = 3\,\Omega$

1.) More resistance when it is going through the bulb as it is being pumped. It also has a charging resistance and to be ohmic resistance must be constant.

2) $I = 250\times10^{-3}\,A$ $\quad R = \frac{V}{I}$

$V = 6.2\,V$

$R = 24.8\,\Omega$ $\quad \alpha = \frac{1}{4.5\times10^{-3}}$

$R = R_0(1 + \alpha\Delta T)$

$24.8\,\Omega = 3\,\Omega(1 + 4.5\times10^{-3}\Delta T)$

$8.266 = 1 + 4.5\times10^{-3}\Delta t\,C^{0-1}$

$7.266 = 4.5\times10^{-3}C^{0-1}\Delta t$

$\Delta t = 1614.81^{0}$

$t_f = 1634.81^{0}C$

Part 3

1.) Regular : V=0.7V I=20mA
Reversed : V=5.0V I=0mA

3.) The diode is not ohmic since the resistance is not constant